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None

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(54) **Method for controlling the distance between moving vehicles**

(57) A method for controlling the distance between a vehicle and another vehicle in front uses any type of distance detection.

In the course of a distance control, by evaluating at least the vehicle's own speed and its steering angle, the driving situation is divided up into a number of classes, and as a function of the classified driving situation a control rule is selected for the dimensioning of the drive force from a number of rules, the situation-dependent control rule for the overall drive force, with which the vehicle is to be controlled to a set distance, being formed as the sum of the individual control rules weighted with classification functions k_i which at least overlap at the edges in terms of their speed ranges (Fig. 2).

Fig. 2

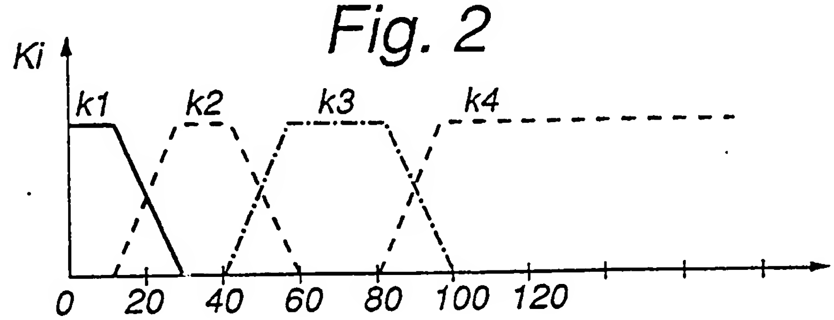

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Fig. 1

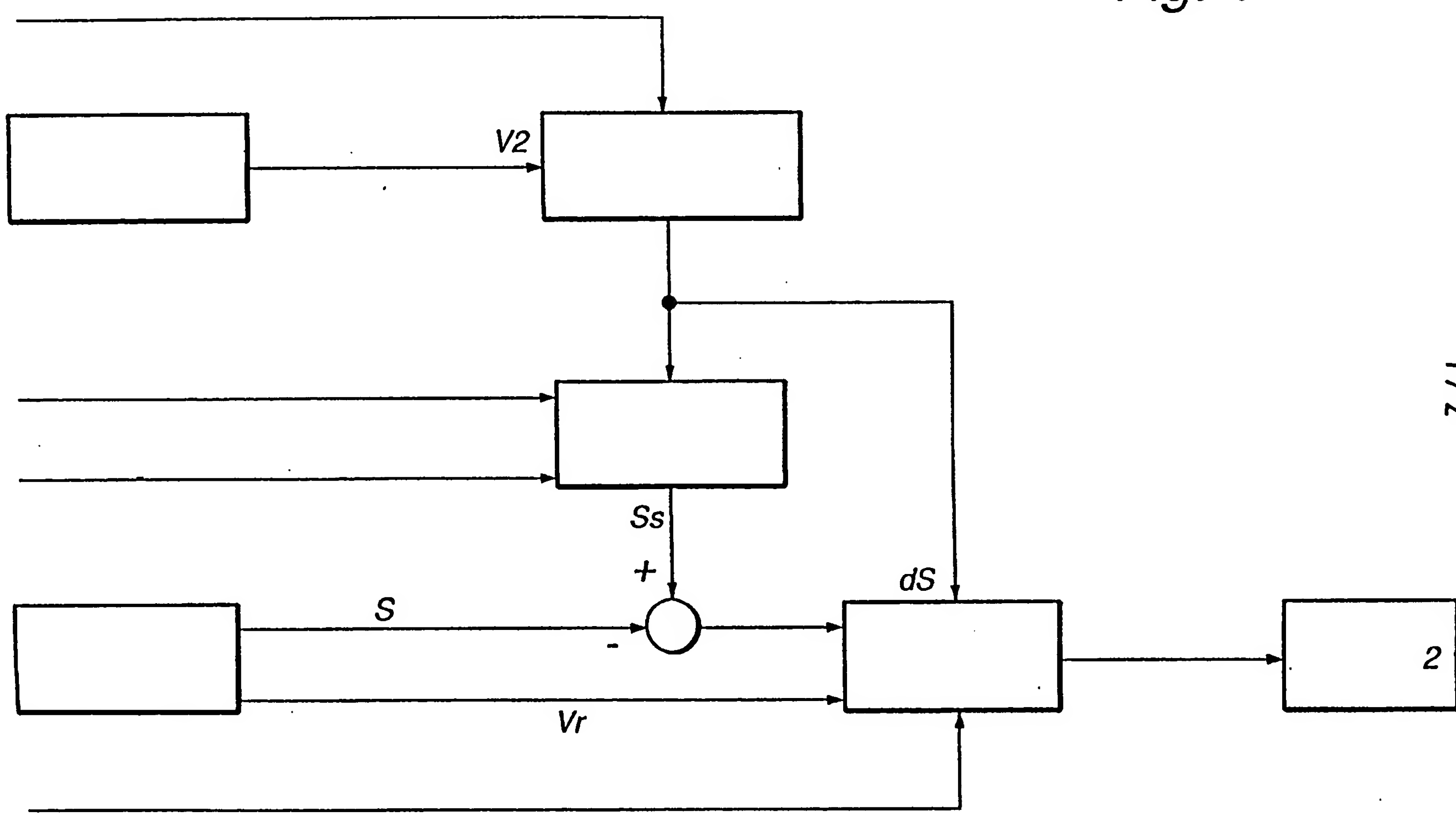


Fig. 2

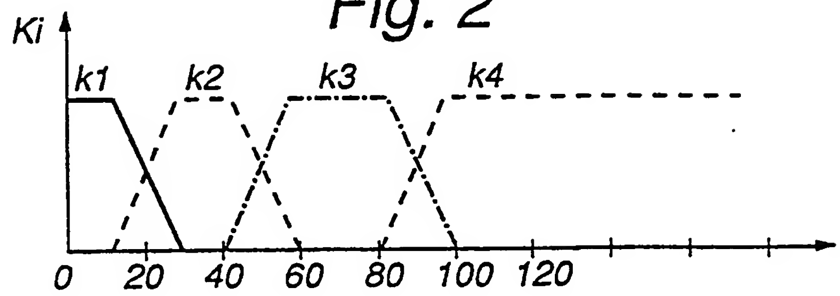


Fig. 3

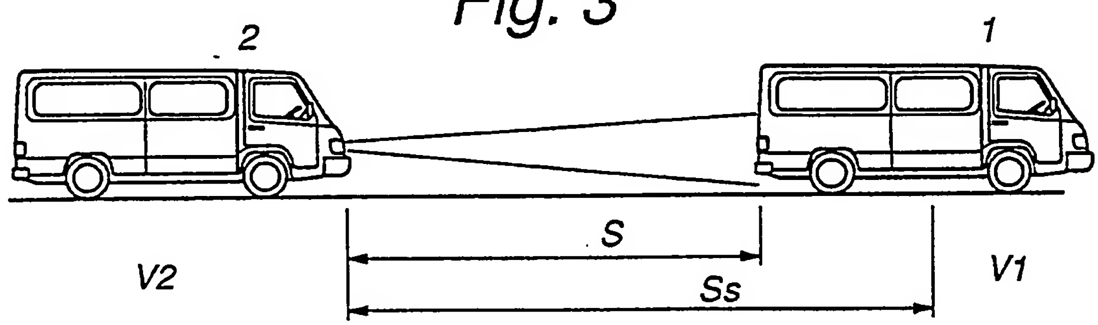
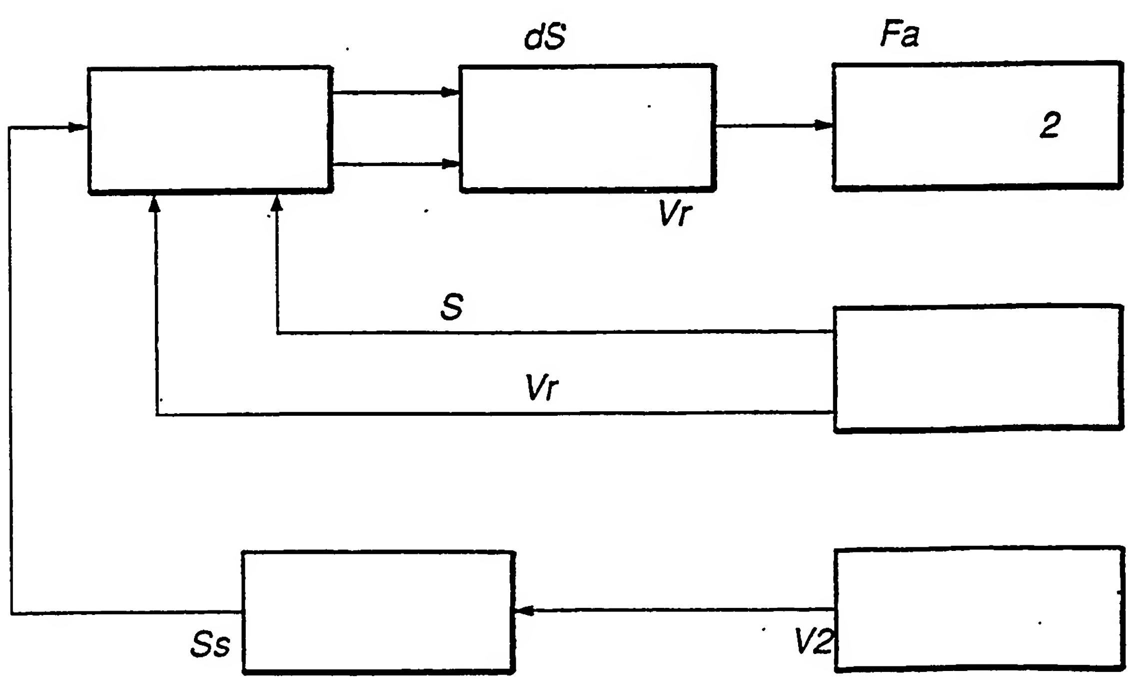


Fig. 4



Method for controlling the distance between moving vehicles

The invention relates to a method for controlling the distance between moving vehicles.

When automatically maintaining the distance between motor vehicles, a speed-dependent set distance is usually observed which is determined by means of a fixed reaction time of the driver. For example, US 5,014,200 describes such a system.

In general, driving takes place in accordance with a fixed control rule while the control behaviour of the driver depends on the driving situation present at the time. The distance S between a vehicle in front and the vehicle behind is generally controlled to a set distance S_s by means of ultrasonic, infrared or mm-wave radar, it being possible for example also to detect the relative speed of the two vehicles with respect to one another by means of the Doppler effect.

Then, $S_s = f\{V_1, V_2, a_1, a_2, T_r\}$ where

- V_1 = speed of the vehicle in front
- V_2 = vehicle's speed
- a_1 = maximum deceleration capacity of the vehicle in front
- a_2 = maximum deceleration capacity of the vehicle behind
- T_r = instantaneous reaction time of the motorist

It is also known to select

$S_s = V_2 * T_r$.

Furthermore, the distance error

$dS = S_s - S$ is determined by comparison; the relative speed calculated from the kinematics of the two vehicles:

$V_r = V_1 - V_2$.

When maintaining a distance control, the set relative speed ideally becomes zero; a negative relative

speed also constitutes to this extent a control deviation. In order to minimise the control deviation, an accelerating or braking drive force is generated by means of a control device which acts on the vehicle behind to the effect of controlling it. Usually, the drive force is influenced as a function of control deviations and amplification factors.

In this context, reference is also made to the German Offenlegungsschrift DE-OS 41 23 110 which deals with a different system in which current values are also transferred to the vehicle from the respective local travel environment, thus for example in order to characterise the grip of the road, speed limits, etc.

However, control behaviours achieved in this way meet with a low level of acceptance by the motorist since, on the one hand, he is accustomed to adapting his driving behaviour to different peripheral conditions such as weather, state of the traffic and personal state of the driver and, on the other hand, would not like continuously to feed his own value inputs into a control system.

The present invention therefore proposes a method for controlling the distance between vehicles which, on the one hand, permits the distance between vehicles to be maintained automatically and yet, on the other hand, also leads to a considerable improvement in the level of acceptance by the motorist.

According to the present invention there is provided a method for controlling the distance between moving motor vehicles, the vehicle behind being equipped with any desired distance detection means and a device for controlling distance with respect to a vehicle in front, the said device being adapted to act on the driving speed, comprising at least the following steps:

(a) the driving situation is divided up into at least two, generally i, classes by evaluating at least the vehicle's own speed V_2;

(b) classification functions k_i which overlap at least at the edges in terms of their speed ranges are

assigned to the i classes;

(c) the selection of a control rule R_i for the dimensioning of the drive force takes place as a function of the classified driving situation

$$R_i = f\ \{dS,\ V_r,\ \text{amplification factors}\}$$

where dS = distance error

V_r = relative speed

from a number of rules, at least 2, generally i, in which case each rule is valid in each case for a quite specific driving situation or class of driving situation;

(d) the situation-dependent control rule for the overall drive force F_a, with which the vehicle is to be controlled to set distance S_s, is formed as the sum of the i individual control rules R_i weighted with the corresponding classification functions k_i:

$$Fa = k_1 * R_1 + k_2 * R_2 + k_3 * R_3 + k_4 * R_4 + \ldots$$

According to the invention, in the course of a distance control by evaluating at least the vehicle's own speed V_2 and the steering angle ß of the vehicle behind, the driving situation is divided up into i classes, as a function of the classified driving situation a control rule R_i is selected for the dimensioning of the drive force from a number of i rules and the situation-dependent control rule for the overall drive force F_a, with which the vehicle is to be controlled to the set distance S_s, is formed as the sum of the i individual control rules R_i weighted with classifying functions k_i which at least overlap at the edges in terms of their speed ranges. It is advantageous that an automatic adaptation of the control behaviour to the current driving situation and, consequently, a considerably improved level of acceptance of a corresponding control with the motorist is achieved.

Preferably, the weather and the driving behaviour of the motorist is also sensed, a situation-dependent reaction time T_s is calculated as a function of the classified driving situation, the weather and the driver's behaviour

and a situation-modified set distance from the vehicle in front is calculated from the said reaction time T_s and at least the vehicle's own speed and the said set distance is specified to the control rule, respectively effective as a function of the driving situation, for the drive force F_a. Here, the degree of attentiveness of the motorist is also advantageously included in the adaptation of the distance control and, to this extent, the protection against collisions is thus optimized.

Further advantages are obtained according to the invention by influencing the calculated reaction time T_s as a function of speed and/or weather and by measuring the lateral acceleration when going round a bend and limiting the drive force in such a way that a set lateral acceleration is not exceeded.

An embodiment of a system suitable for carrying out the method will now be described by way of example with reference to the drawings in which:

Figure 1 shows a diagrammatic block functional diagram of a distance control system suitable for carrying out the method;

Figure 2 shows an exemplary and diagrammatic illustration of classifying functions k_i which overlap at the edges in terms of their speed ranges;

Figure 3 shows an illustration of two vehicles, one following the other at the distance S;

Figure 4 shows a diagrammatic block functional diagram of a conventional distance control system.

According to Figure 3, a vehicle 2 behind follows, at the distance S and at the speed V_2, a vehicle 1 in front which is travelling ahead at the speed V_1. Here, a distance S is achieved which is smaller than the set distance S_s.

Assuming the constancy of V_1, a negative drive force, i.e. a braking force must therefore be exerted on the vehicle 2 in order to achieve a reduction in the control deviation of the distance controller.

Conventionally, according to Figure 4 a speed measuring device outputs the speed V_2 of the vehicle behind. From this, the set distance S_s is calculated. The latter is fed to a comparator. The (momentary) distance S is also fed to this comparator from a measuring device, for example a radar unit. The control deviation is formed by comparison. The relative speed V_r between the two vehicles is fed to the comparator from the said measuring device. The said speed can also influence in the comparator, in the amplifying or attenuating direction, the control deviation dS which arises. In the case illustrated in the figure, the relative speed is however passed on to the controller and a control device for influencing the drive force, and corresponding influencing is brought about, for example only in the controller to which the distance error dS is fed from the comparator. The control device can be the throttle valve, injection pump, if appropriate with characteristic diagram connected upstream, or a brake actuation valve for example of an electric brake system or one which acts with pressure medium and is equipped with pressure medium reservoir.

In a system according to Figure 1 which is suitable for carrying out the method, the steering angle ß and the speed V_2 obtained from a speed measuring device are subjected to a function for classifying the driving situation. The resulting driving situation class is input on the one hand into a function block for calculating the set distance and into the controller with control device for the drive force F_a which influences the distance. The set distance calculation can take place via the calculation of a driving situation-dependent reaction time T_s for the motorist.

The function block for calculating the set distance is also fed at least one variable which characterises the driver's behaviour and one variable which characterises the weather. A measuring device transmits the distance S to the vehicle in front and the relative speed between the two

vehicles. The set distance S_s and distance S are compared with one another and the resulting distance error dS and the relative speed V_r are fed to the controller with control device. The control device can also here be the throttle valve, injection pump, if appropriate with characteristic diagram connected upstream, or a brake actuation valve, for example of an electric brake or ASR system or one which acts with pressure medium and is equipped with a pressure medium reservoir. Furthermore, the controller can also be fed the detected lateral acceleration. The drive force which is effected or influenced in this way acts on the vehicle 2 with the effect of controlling the distance from the vehicle 1 in front.

Figure 2 shows classification functions k_i which overlap at the edges in terms of their speed ranges for the weighting, in terms of the speed ranges, of individual control rules R_i for the drive force F_a such as are used in the method.

The method according to the invention for controlling the distance between moving motor vehicles is not tied to a special distance detection system; to this extent, it can be carried out for example by means of an optical radar or an m-wave radar of any kind, provided it is suitable for emitting a distance and relative speed signal.

The method comprises the following steps:

a. By evaluating at least the vehicle's own speed V_2 and the steering angle ß, the driving situation is divided up into at least two, generally i classes.

b. Classification functions k_i which overlap at least at the edges in terms of their speed ranges are assigned to the i classes.

c. The selection of a control rule R_i for the dimensioning of the drive force takes place as a function of the classified driving situation

$R_i = f$ {dS, V_r, amplification factors) where

dS is the distance error
V_r is the relative speed

from a number of rules, at least 2, generally i, in which case each rule is valid in each case for a quite specific driving situation or driving situation class.

d. The situation-dependent control rule for the overall drive force F_a, with which the vehicle is to be controlled to set distance S_s, is formed as the sum of the i individual control rules R_i weighted with the corresponding classification functions k_i, as follows:

$$Fa = k_1 * R_1 + k_2 * R_2 + k_3 * R_3 + k_4 * R_4 + \ldots$$

.

An even better level of acceptance by the motorist of such a control is achieved if the weather and the instantaneous driver's behaviour is also included in the set distance specification for the controller, as follows:

e. The weather and the driver's behaviour are sensed.

f. A situation-dependent reaction time T_s is calculated as a function of the classified driving situation, the weather and the driver's behaviour.

g. A reaction-modified set distance S_s from the vehicle in front is calculated as a control variable, for example according to the following minimum specification:

$$S_s = V_2 * T_s.$$

h. The distance S from the vehicle in front is controlled to this reaction time-modified set distance.

A further refinement of the method is achieved in that

i. the reaction time T_S is selected to be smaller in a typical in-town driving situation and/or at low speeds than at high speeds on a motorway.

A further improvement of the method is achieved if

k. the reaction time T_S is increased in bad weather and/or when the driver is inattentive, and reduced when the opposite is true.

A further refinement of the method is achieved in that

l. the lateral acceleration is measured and the drive force is restricted when going round a bend in such a way that a set limit lateral acceleration is not exceeded.

Claims

1. A method for controlling the distance between moving motor vehicles, the vehicle behind being equipped with any desired distance detection means and a device for controlling distance with respect to a vehicle in front, the said device being adapted to act on the driving speed, comprising at least the following steps:

(a) the driving situation is divided up into at least two, generally i, classes by evaluating at least the vehicle's own speed V_2;

(b) classification functions k_i which overlap at least at the edges in terms of their speed ranges are assigned to the i classes;

(c) the selection of a control rule R_i for the dimensioning of the drive force takes place as a function of the classified driving situation

$$R_i = f\ (dS,\ V_r,\ \text{amplification factors})$$

where dS = distance error

V_r = relative speed

from a number of rules, at least 2, generally i, in which case each rule is valid in each case for a quite specific driving situation or class of driving situation;

(d) the situation-dependent control rule for the overall drive force F_a, with which the vehicle is to be controlled to set distance S_s, is formed as the sum of the i individual control rules R_i weighted with the corresponding classification functions k_i:

$$Fa = k_1 * R_1 + k_2 * R_2 + k_3 * R_3 + k_4 * R_4 + \dots$$

.

2. A method according to Claim 1, including the following further steps:

(e) the weather and the driver's behaviour are sensed;

(f) a situation-dependent reaction time T_S is calculated as a function of the classified driving situation, the weather and the driver's behaviour;

(g) a reaction-modified set distance from the vehicle in front is calculated as a control variable at least according to the following minimum rule:

$$S_S = V_2 * T_S;$$

(h) the distance S from the vehicle in front is controlled to this reaction-modified set distance.

3. A method according to Claim 2, including the following further step:

(i) the reaction time T_S is selected to be smaller in a typical in-town driving situation and/or at low speeds than at high speeds on the motorway.

4. A method according to Claim 2, including the following further step:

(k) the reaction time T_S is increased in bad weather and/or when the driver is inattentive and reduced when the opposite is true.

5. A method according to Claim 1, including the following further step:

(l) by measuring the lateral acceleration, the drive force is limited when going round a bend in such a way that a set limit lateral acceleration is not exceeded.

6. A method for controlling the distance between moving motor vehicles, substantially as described herein with reference to, and as illustrated in, the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
GB 9305325.4

Relevant Technical fields	Search Examiner
(i) UK Cl (Edition L) G4Q (QCF)	M J DAVIS
(ii) Int Cl (Edition 5) G08G	
Databases (see over)	Date of Search
(i) UK Patent Office	27 APRIL 1993
(ii)	

Documents considered relevant following a search in respect of claims 1-6

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

Category	Identity of document and relevant passages	Relevant to claim(s)

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